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Surveys and Needs Assessments

Nebraska Growers' and Crop Consultants' Knowledge and Implementation of Integrated Pest Management of Western Bean Cutworm

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Abstract

Western bean cutworm (WBC), *Striacosta albicosta* (Smith; Lepidoptera: Noctuidae), is a native noctuid pest of corn and dry beans in North America. While this pest has expanded its range greatly in recent years, historically it has consistently caused high yield losses in western Nebraska. A survey was distributed to growers, crop consultants and other agricultural professionals to obtain information about current management practices used for WBC. Questions covered multiple topics including: demographics, scouting practices, degree-day model use, confidence in management knowledge, Bt corn use, insecticide use, and considerations for biological control. There were 95 completed responses received by email. Respondents self-reported a significantly higher yield loss due to WBC in 2016 than in 2015 and 2014. Growers demonstrated less knowledge of WBC identification and management than crop consultants. There were frequent (58.45%) reports of Cry1F Bt corn providing decreased control against WBC. This survey identified major concerns for growers and agricultural professionals in Nebraska for WBC management. An improved understanding of WBC biology and education on management would be most beneficial for growers. Crop consultants would benefit from using more diverse management tactics including: biological control, rotation of insecticide mode-of-action, and diversifying Bt corn types.

Key words: survey, *Striacosta albicosta*, field crop pests, resistance management

Western bean cutworm (WBC), *Striacosta albicosta* (Smith; Lepidoptera: Noctuidae), is a native lepidopteran pest of corn and dry beans. Traditionally it has been an economically damaging pest in western Nebraska, Kansas, and eastern Colorado. However, beginning in 1999, WBC populations began to expand into the eastern Corn Belt, Canada, and Texas and Mexico (O'Rourke and Hutchison 2000, Catangui and Berg 2006, Baute 2009, Miller et al. 2009, Sánchez-Peña et al. 2016). This pest can cause severe damage to corn, causing up to 3.7 to 15 bushel/acre yield losses and opening the ear to fungal damage (Appel et al. 1993, Seymour et al. 2010, Paula-Moraes et al. 2013, Parker et al. 2017). The potential for severe damage and expanding geographic range has made WBC an increasing concern for many growers, and so research and Extension efforts have been made to develop improved management programs in Nebraska and elsewhere.

Integrated pest management (IPM) programs for WBC have thus far focused on using scouting plus the application of broad-spectrum insecticides and Bt corn with Cry1F and Vip3A traits (Eichenseer et al. 2008, Michel et al. 2010). However, in recent years, growers and stakeholders in Nebraska and the Great Lakes states (DiFonzo et al. 2016, Peterson 2016) have expressed concerns over the efficacy of these methods. Over the 10-yr period between 2003 and 2013 there has been a 5.2-fold decrease in efficacy for the Cry1F trait against WBC in parts of Nebraska and Iowa (Ostrem et al. 2016). A recent study has also reported evidence for field-evolved resistance to Cry1F protein by WBC in Ontario, Canada (Smith et al. 2017). Some stakeholders in Nebraska have also voiced concerns about the potential decreased efficacy of common synthetic pyrethroid insecticides.

Scouting and thresholds are an integral part of WBC management. The current threshold for field corn is 5–8% infested plants (Paula-Moraes et al. 2013). Use of scouting and thresholds prior to insecticide treatments helps delay resistance, and avoid unnecessary expenditures. In addition, scouting can target application timing to provide increased efficacy for chemical control. However, stakeholders vary in their ability and willingness to scout for WBC prior to treatment. Recommended techniques include sequential sampling or consecutive sampling of 20 plants in five areas of the field (Paula-Moraes et al. 2011).

Surveys have been used in Extension to determine stakeholders' pest management concerns, analyze IPM practices and evaluate the effectiveness of programs (Givens et al. 2009). This survey analyzes how growers and crop consultants understand and practice IPM of WBC. This survey also determines the Extension-based needs of stakeholders in Nebraska with regards to WBC.

Materials and Methods

Survey Design

A 40-question survey was designed and divided into six sections: 1) general questions about respondent demographics, professional agricultural history, and yield loss due to WBC; 2) scouting practices, pest identification and degree-day models; 3) confidence in management practices; 4) Bt corn type use; 5) insecticide use; and 6) biological control and natural enemies. Questions were formatted as either multiple choice with single answer options, multiple choice with multiple answer options, or open text entry.

The survey was built and distributed using Qualtrics software, version 06/2016-06/2017 (Qualtrics, Provo, UT). Prior to general release, to determine the face validity of the survey, questions were reviewed by 15 individuals, including members of the Nebraska Field Office of the U.S. Department of Agriculture's National Agricultural Statistics Service (USDA-NASS), University of Nebraska-Lincoln Department of Entomology faculty and graduate students (including specialists in IPM, extension, and survey development), and Nebraska crop consultants. An IRB application was submitted and approved for the survey and the emails used in distribution (IRB#20160816253 EX).

Survey Distribution

Links to the survey were sent to the email distribution lists of the Nebraska Independent Crop Consultant Association (NICCA) (n = 160) and the Nebraska Corn Board (NCB) (n = 1,290). Initial emails were sent on 2 December 2016 (to NICCA) or 12 December 2016 (to NCB). Follow-up email reminders were sent on 28 December 2016 and 11 January 2017. The survey closed on 2 February 2017. To incentivize participation, those whom completed the survey were entered in a drawing for two University of Nebraska-Lincoln football tickets.

Data Analysis

Data was analyzed using cross-tabulation functions in Qualtrics software, version 06/2016-06/2017 (Qualtrics). Chi-Square values were calculated to indicate significant response comparisons.

Results

Distribution of Responses

Demographic information was collected from respondents to evaluate if agricultural profession affects how stakeholders are implementing WBC management practices. Although 121 responses were initiated, 94 were completed. The distribution of respondents' age in years at the time of taking the survey was: 14.8% age 19–30; 24.4% age 31–45; 53.9% age 46–64; and 7.0% age 65 or greater. The profession of survey respondents was: 32.2% crop consultant, 47.0% grower, and 20.9% other (which included individuals who selected more than one profession).

Although most of the survey respondents had greater than 20-yr experience as a crop consultant or grower, a variety of experience levels were represented (Fig. 1). Growers with greater than 20-yr experience as an agricultural professional were our most represented group (30.4%) followed by crop consultants with greater than 20-yr experience (18.3%). Most of the respondents (61.7%) had greater than 20-yr experience in their agricultural professions.

Respondents managed one or more fields in 65 of the 93 counties (68.9%) in Nebraska (Fig. 2). These counties are representative of major corn producing areas in Nebraska. The highest number of respondents (21) managed one or more fields in Buffalo County. Respondents also managed one or more fields in Kearney (15), Hall (11), and Phelps (11) counties. Most of the respondents from these concentrated areas around Buffalo County are crop consultants.

Respondents from southwest Nebraska (Chase, Dundy, Hitchcock, and Hayes Counties) were under-represented in the survey. These areas experience frequent WBC infestation and damage but only a small number of respondents indicated that they manage one or more fields in that area. The Nebraska Panhandle experiences high damage in dry beans due to WBC but that region had a low level of respondents managing one or more fields in those counties.

WBC Damage in 2014–2016

Respondents reported higher perceived yield loss in 2016 than in 2015 and 2014 (χ^2 = 14.80, df = 6, P = 0.02) (Fig. 3). In 2014, 61.1% of respondents experienced no damage due to WBC infestation and another 30.5% experienced a minimal damage of 1–2 bushels/acre. Yield loss in 2015 was higher than 2014. Less than half of respondents (44.2%) experienced no yield loss due to WBC. However, 29.5% experienced 1–2 bushels/acre yield loss and 26.3% reported a yield loss of 3–14 bushels/acre. More respondents believe they experienced more damage due to WBC in 2016 than previous years. Only 30.5% experienced no yield loss from WBC and 40% of respondents experienced yield loss of 3–14 bushels/acre. Nearly 10% (9.5%) reported yield losses higher than 15 bushels/acre.

Scouting Practices

Scouting and use of economic thresholds is recommended prior to WBC insecticide treatments in Nebraska (Paula-Moraes et al. 2013). Agricultural professionals were asked whether scouting is practiced in the fields that they manage. Crop consultants (97.5%) and other

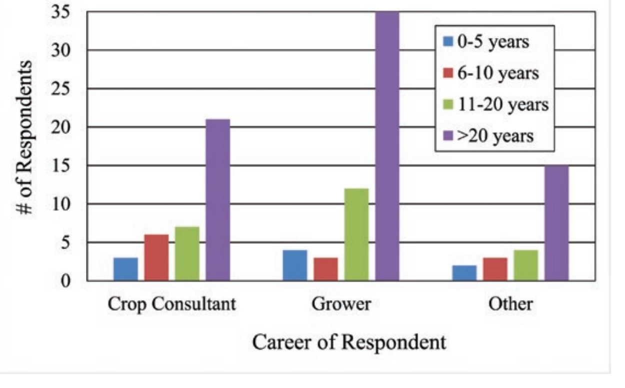

Fig. 1. The agricultural profession of respondents and their length of time as an agricultural professional.

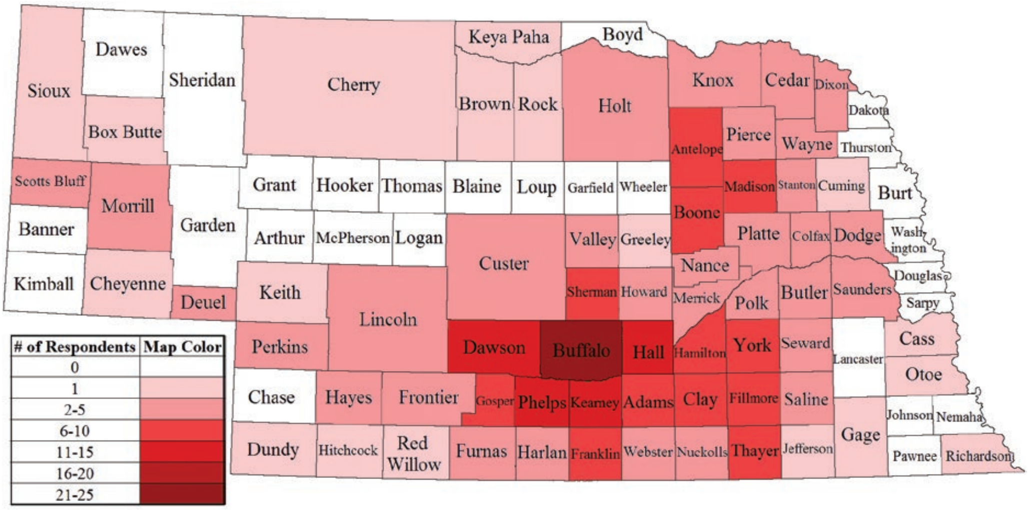

Fig. 2. Counties where respondents reported managing one or more fields.

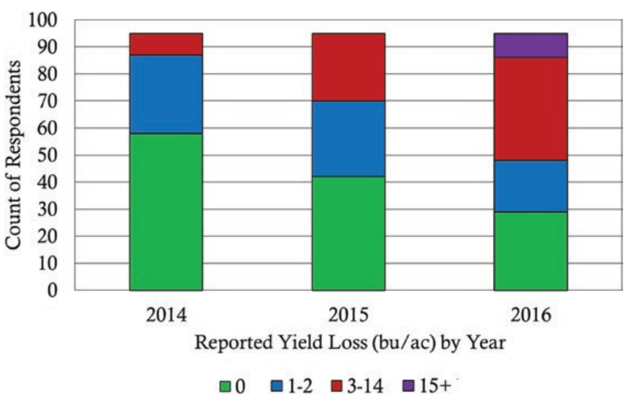

Fig. 3. Respondents' reports of average corn yield loss due to western bean cutworm in 2014, 2015, and 2016.

agricultural professionals (76.9%) were significantly more likely than growers (32.6%) to scout the fields they manage for WBC (χ^2 = 40.41, df = 2, P < 0.001). Most grower respondents (63.0%) prefer to hire another individual to do scouting for WBC. Adherence to recommended WBC scouting practices was significantly higher for crop consultants and other agricultural professionals than for growers (Table 1).

All crop consultants and other occupations (100.0%) felt that scouting was either extremely effective or somewhat effective as a practice of informing them about WBC risk. Nearly all growers (83.7%) believed that scouting was an effective practice for determining the presence of the pest. Few grower respondents felt that scouting was ineffective (4.7%) and another minority (11.6%) were unsure about the efficacy of scouting in determining the presence of WBC in a field.

There was a significant difference between crop consultants, growers and other agricultural professionals in their ability to identify WBC eggs, larvae and adults. Participants were asked to select the WBC egg mass from a photo array that also included eggs of fall armyworm (*Spodoptera frugiperda* [J. E. Smith; Lepidoptera: Noctuidae]), European corn borer (ECB) (*Ostrinia nubilalis* [Hübner; Lepidoptera: Crambidae]), and Pentatomidae. Crop consultants (82.5%) were more successful than growers (43.9%) and other agricultural professionals (50.0%) at identifying WBC eggs (χ^2 = 16.94, df = 6, P = 0.01). Participants were asked to select the late instar WBC larva from a photo array that also included an ECB larva, corn earworm larva (*Helicoverpa zea* [Boddie; Lepidoptera: Noctuidae]) and a Diplopod. Crop consultants (92.5%) and other agricultural professionals (100.0%) performed significantly better than growers (63.4%) at identification of WBC larvae (χ^2 = 14.02, df = 6, P = 0.03). Participants were asked to select the WBC moth from a photo array that also included an ECB moth, corn earworm moth and western corn rootworm beetle *Diabrotica virgifera virgifera* (LeConte; Coleoptera: Chrysomelidae). Crop consultants (80.0%) were also significantly better at identifying WBC adults than growers (24.4%) and other agricultural professionals (50.0%). The photo of the corn earworm moth was the most selected incorrect option by 41.5% of growers and 50.0% of other professionals (χ^2 = 30.90, df = 6, P = 0.001).

Degree-day Models

Most respondents (50.6%) reported that they do not use degree-day models (Hanson et al. 2015) to predict when to start scouting and treating for WBC. Another 36.0% of respondents have used degree-day models but they do not feel confident about using them effectively. The respondents in this category were 21.9% other agricultural professionals, 40.6% growers and 40.6% crop consultants. Only 13.5% of respondents felt confident using degree-day models effectively and 91.7% of them were crop consultants.

Most participants who feel confident using degree-day models (75.0%) begin scouting for WBC at 0–25% moth flight. Participants who do not feel confident using degree-day models (53.1%) are less likely to use moth flight as an indicator for when to begin scouting for WBC. Those who did use moth flight as an indicator (36.0%) began scouting at 0–25% moth flight. This was the case even when some participants had never used degree-day models (24.4%). Overall it was most common for growers, crop consultants and other agricultural professionals to not use degree-day models as an indicator for WBC scouting (44.9%).

Confidence With Managing WBC

Growers felt less confident about their knowledge of WBC management practices than crop consultants and other agricultural professionals (χ^2 = 26.47, df = 6, P < 0.001). Crop consultants were very confident (55.0%) or somewhat confident (40.0%) about their knowledge of WBC management practices. Growers were less sure about this knowledge: 12.2% very confident, 48.8% somewhat confident, 26.8% somewhat unconfident, and 12.2% very unconfident.

Bt Corn Performance in Nebraska

Crop consultants (87.9%) and other agricultural professionals (100.0%) report that Bt corn provided reduced control of WBC in the 2014–2016 field seasons than it did during the previous field seasons. However, most growers (54.8%) reported that Bt corn continues to provide the same level of control against WBC in the 2014–2016 field seasons as it did in previous years. Respondents who reported experiencing higher yield loss in 2016 than 2014 and 2015, were also more likely to report that Bt corn types are providing less control of WBC than in the past ($\chi^2 = 14.69$, df = 6, $P = 0.02$).

Use of Bt Corn in Nebraska

Most respondents (76.4%) planted Bt corn that expresses proteins that target WBC. Most of the available Bt corn targeting WBC utilizes the Cry1F trait (75%) and some types use the Vip3A trait individually or in a pyramid (25%) (Difonzo 2017). Corn that utilizes only Cry1F represented 87.5% of the seed types planted by respondents; only 10.1% used Vip3A and 2.4% used a pyramid of Vip3A and Cry1F.

Over 70% of their users reported decreased efficacy (Table 2) for four of the top six Bt corn types in Nebraska. Of the 16 available types that target WBC, 6 of them account for 72.0% of reported Bt corn use. On the reports for these six types, 70.2% of users on average reported decreased efficacy. Agrisure Viptera 3111 and 3110, the two types with Vip3A, had 10% of cases reported with lower efficacy.

Insecticide Use in Nebraska

Crop consultants were more likely than farmers to have used insecticides for WBC in the 2014–2016 field seasons ($\chi^2 = 26.92$, df = 6, $P < 0.001$). Between 2014 and 2016, 42.5% of crop consultants treated all 3 yr, 30.0% treated for 2 yr, 15.0% treated in only 1 yr, and 12.5% have not used insecticide treatments for WBC in the last 3 yr. The inverse was true for growers. Between 2014 and 2016, 9.8% of growers treated all 3 yr, 12.2% treated for 2 yr, 17.1%

Table 1. WBC scouting practices that were conducted by respondents between 2014 and 2016

Scouting practice	%Grower (N = 38)	%Crop consultant (N = 39)	% Other agr. professional (N = 12)	% Total for practice (N = 85)
Look for WBC egg masses on upper surfaces of leaves and whorl	71.1	100.0	91.7	85.9
Scout fields before or during pollen shed	57.9	100.0	91.7	80.0
Scout multiple fields for WBC	60.5	89.7	91.7	77.7
Scout at least once a week starting in late June	47.4	89.7	75.0	69.4
Check 20 plants in at least five parts of each field	52.6	76.9	83.3	65.9
Continue scouting for 7–10 d after detecting WBC	39.5	84.6	66.7	62.4
Use the light trap data published online by the University of Nebraska- Lincoln	10.5	48.7	75.0	36.5
Use pheromone traps or light traps to see when WBC moths are flying	7.9	15.4	25.0	14.1
Place pheromone traps or light traps in June before adults begin laying eggs	5.3	10.3	8.3	8.2
% of Total by Occupation	44.7	45.9	14.1	

Table 2. List of Bt trait trade names that are registered to target WBC with Cry1F, Vip3A, or both proteins, with the number of respondents reporting having planted/managed each trait and perceptions of lower efficacy

Trade name	Relevant traits	# of respondents indicating management with trade name (N = 67)	% Reporting lower efficacy (N = 46)
Herculex XTRA (HXX)	Cry1F	48	68.8
Herculex 1 (HX1)	Cry1F	44	75.0
Genuity SmartStax RIB complete	Cry1F	33	51.5
AcreMax Xtra (AMX)	Cry1F	31	71.0
AcreMax Xtreme (AMXT)	Cry1F	31	74.2
AcreMax TRIsect (AMT)	Cry1F	26	80.8
Agrisure Viptera 3111	Vip3A	18	5.6
TRIsect	Cry1F	17	70.6
Agrisure Viptera 3110	Vip3A	12	16.7
Intrasect	Cry1F	11	36.4
Agrisure 3122 E-Z Refuge	Cry1F	6	16.7
Intrasect Xtra	Cry1F	5	60.0
Agrisure Duracade 5222 E-Z Refuge	Cry1F, Vip3A	4	0.0
Intrasect Xtreme	Cry1F	4	25.0
Agrisure Duracade 5122 E-Z Refuge	Cry1F	3	0.0
Intrasect Leptra	Cry1F, Vip3A	3	0.0
Total		296	58.5

treated in only 1 yr, and 61.0% have not used insecticide treatments for WBC in the last 3 yr.

Nearly all of the respondents (91.1%) only sprayed one insecticide treatment per season during 2014–2016. Most respondents (80.4%) were also consistent about 'always' or 'usually' checking fields for spider mites prior to insecticide applications to avoid increasing mite infestations.

There is a significant split among agricultural professionals about whether insecticides have been providing less control against WBC. Over half of the respondents (58.9%) reported no change in efficacy. Among those were 88.9% of other agricultural professionals, 73.3% of growers, and 48.6% of crop consultants. Among the 39.3% that reported decreased insecticide efficacy against WBC, it was 51.4% of the crop consultants and 26.7% of the growers ($\chi^2 = 13.27$, df = 6, $P = 0.01$). Nearly all the insecticides used by respondents were pyrethroid insecticides (81.0%) (Table 3).

Consideration of Biological Control and Natural Enemies

When agricultural professionals were asked whether they use insecticides that are nontoxic to natural enemies, 27.3% of respondents 'sometimes' used them and 29.6% used them rarely. The most common response (31.8%) was, 'I don't know which insecticides are nontoxic to predators but if I did I would use those insecticides'. Growers (64.3%) were the agricultural professionals that expressed the highest interest in insecticides that are nontoxic to natural enemies. Some of the agricultural professionals in Nebraska (10.2%) usually use insecticides that are nontoxic to predators.

Discussion

A primary finding of this survey is that growers are less involved with scouting and WBC management than crop consultants. It is evident that most growers prefer to hire other individuals to scout for WBC. A similar survey of growers in Illinois found that 65% of farmers hire a professional pesticide applicator to scout before spraying insecticides (Czapar et al. 1995). Wright et al. (1997) also indicated that crop consultants are doing much of the scouting and making more of the IPM decisions for growers in the Midwestern United States. Even among those growers who scout their own fields (32.6%), they are still less likely than crop consultants to implement recommended scouting practices. This lack of awareness about WBC is also evident in growers' ability to identify the pest. When presented with images of the egg, larval and adult stages, growers demonstrated a significant inability to identify the pest. Nearly all crop consultants excelled at practicing proper scouting practices and identifying WBC at various life stages. There is a significant knowledge gap between growers and crop consultants regarding practices for WBC management. This knowledge gap may have developed because of the more specialized roles between growers and crop consultants. As agriculture increases in scale, growers take more of

Table 3. Insecticides used by respondents between 2014 and 2016. There were 153 reports of insecticides used.

Insecticide name	Active ingredient	Class, IRAC Code	# of Reports	% Reporting lower efficacy
Brigade 2EC	bifenthrin	Pyrethroids, 3A	43	30.2
Hero	bifenthrin + zeta-cypermethrin	Pyrethroids, 3A	28	53.6
Mustang Maxx	zeta-cypermethrin	Pyrethroids, 3A	20	30.0
Capture 2EC	bifenthrin	Pyrethroids, 3A	12	16.7
Warrior	lambda-cyhalothrin	Pyrethroids, 3A	11	9.1
Lorsban Advanced	chlorpyrifos	Organophosphates, 1B	10	0.0
Chlorpyrifos	chlorpyrifos	Organophosphates, 1B	9	0.0
Prevathon	chlorantraniliprole	Diamides, 28	7	0.0
Pounce 3.2 EC	permethrin	Pyrethroids, 3A	5	40.0
Hero EW	bifenthrin + zeta-cypermethrin	Pyrethroids, 3A	3	33.3
Bacillus thuringiensis	*Bacillus thuringiensis*	Biological Insecticide, 11	2	50.0
Cobalt	chlorpyrifos + lambda-cyhalothrin	Organophosphates, 1B + Pyrethroids, 3A	1	0.0
Mustang EW	zeta-cypermethrin	Pyrethroids, 3A	1	0.0
Lannate	methomyl	Carbamates, 1A	1	0.0
Asana XL	esfenvalerate	Pyrethroids, 3A	0	0.0
Baythroid XL	beta-cyfluthrin	Pyrethroids, 3A	0	0.0
Blackhawk Naturalyte	spinosad	Spinosyns, 5	0	0.0
Dipel	*Bacillus thuringiensis*	Biological Insecticide, 11	0	0.0
Force	tefluthrin	Pyrethroids, 3A	0	0.0
FyFanon	malathion	Organophosphates, 1B	0	0.0
Intrepid 2F	methoxyfenozide	Diacylhydrazines, 18	0	0.0
Proaxis	gamma-cyhalothrin	Pyrethroids, 3A	0	0.0
Radiant SC	spinetoram	Spinosyns, 5	0	0.0
Sevin XLR Plus	carbaryl	Carbamates, 1A	0	0.0
Spinosad	spinosad	Spinosyns, 5	0	0.0
Stallion Brand	zeta-cypermethrin + chlorpyrifos	Pyrethroids, 3A + Organophosphates, 1B	0	0.0
Tracer	spinosad	Spinosyns, 5	0	0.0
Triple Crown	zeta-cypermethrin + bifenthrin + imidacloprid	Pyrethroids, 3A + Neonicotinoids 4A	0	0.0

an administrative business role and rely on specialists like crop consultants to oversee pest management (Czapar et al. 1995).

Degree-day models and light trap survey data are two tools provided by University of Nebraska-Lincoln to aid agricultural professionals in Nebraska with scouting for WBC. The degree-day models for WBC were improved by Hanson et al. (2015), and have been used in Nebraska to predict the flight times of WBC moths and subsequent oviposition. The UNL online publication CropWatch (http://cropwatch.unl.edu) has released articles prior to WBC moth emergence to help agricultural professionals determine when to begin scouting for WBC (Peterson et al. 2015, 2016, 2017). Despite this resource being available, over 50% of respondents do not use degree-day models to determine when to scout and treat for WBC. Most individuals who do use degree-day models feel unsure about how to use the tool effectively. Efforts to educate stakeholders on the use of degree-day models may be helpful for improved efficiency in WBC management. When seeking information about pest management, growers prefer to get information from one-on-one consultations, workshops, and field days (Arbuckle 2017). Similar preferences for information sources would most likely also apply for WBC management. Those individuals who do not use degree-day models most likely decide when to scout based on professional recommendation or personal experience. Applying this principle, teaching growers and crop consultants how to use degree-day models would be most effective in a workshop rather than a publication.

When crop consultants and growers were asked about the current performance of Bt traits against WBC, 58.5% of the 296 responses reported decreased control. Most of these reports (98.3%) indicated that Cry1F is providing less control against WBC in the 2014–2016 seasons than it has in previous seasons. At its introduction, Cry1F provided only around 80% control of WBC (Seymour et al. 2010). The reports of decreased efficacy are consistent with the findings of Ostrem et al. (2016) and Smith et al. (2017), which confirmed decreased susceptibility of some WBC populations to Cry1F. Losing this trait is a major concern for many growers, particularly considering that 87.5% of respondents' reports of trait usage in this survey (Table 2) and 75% of all commercially available U.S. Bt corn types marketed for WBC control (DiFonzo 2017) express only Cry1F for WBC. There was one report of decreased efficacy for Agrisure Viptera 3111 and two reports of decreased efficacy for Agrisure Viptera 3110; these two types use Vip3A traits. While there are a few reports of perceived decreased efficacy from this survey, there have been no additional published research that supports this observation.

Over one-third of respondents (41.1%) reported that there has been decreased insecticide efficacy against WBC in Nebraska. The most reported and most used insecticides in Nebraska are pyrethroid insecticides with bifenthrin and/or zeta-cypermethrin as active ingredients. Ongoing research in Nebraska is exploring this concern (Montezano et al. 2016, 2017a,b). Although there is not currently evidence of decreased insecticidal efficacy, there is a need to diversify insecticides and modes-of-action in Nebraska to preserve the efficacy of pesticides against WBC.

Some grower respondents (64%) indicated an interest in using insecticides that were nontoxic to predators if they knew which insecticides these were. However, crop consultants expressed less interest with only 22.5% expressing a willingness to use those insecticides. This willingness to use insecticides that are nontoxic to predators offers a future for conservation biological control as part of an IPM program for WBC. However, this change will be difficult to implement while crop consultants make most pest management decisions and growers remain uninformed about WBC management. In addition, products with reduced toxicity to natural enemies may not have the same efficacy, residual activity, or cost more per acre than broad-spectrum products (Klein 2017), so economic and practical feasibility of this option needs to be explored prior to adoption. This survey did not define for participants which insecticides are considered to be nontoxic to natural enemies; therefore, respondents needed to use their own knowledge when answering this question. Further study to determine the current knowledge level of agricultural professionals regarding reduced risk pesticides and their likelihood for including these products in an IPM program are needed.

For Extension efforts and WBC management to be effective, it is imperative that programs take into account the different knowledge levels of crop consultants and growers to reconcile the needs of both these important stakeholder groups. Crop consultants have high scouting competence, but poor willingness to adopt chemical rotation or products with lower toxicity to beneficial insects. Growers need improved education opportunities regarding scouting, pest management, and the value of conserving beneficial insects. Focused education for those 45% of growers that are willing to use insecticides with reduced toxicity to natural enemies could have positive outcomes for the conservation of beneficial arthropods and the ecosystem services that they provide, such as biological control, pollination, and nutrient cycling. In addition, grower education focused on IPM could increase confidence in addressing WBC issues and allow growers to engage at a higher level with crop consultants and in making management decisions on their farms.

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